Title: Modeling and optimizing XeF{sub 2}-enhanced FIB milling of silicon.
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Abstract: Wide variations in the dose enhancement factor observed when milling silicon using focused ion beam (FIB) XeF{sub 2} gas assisted etching (GAE) prompted the development of a simple model of the GAE process. The model accounts for three material removal mechanisms: regular sputtering; gas-assisted sputtering; and spontaneous chemical reactions. An expression linking the dose enhancement factor, epsilon {sub d}, to the gas and milling parameters has been derived. Experiments show that epsilon {sub d} behaves as predicted; good quantitative agreement is achieved over wide ranges of milling parameters for epsilon {sub d} values between 20* and 2500*. Conditions required to minimize variations in d and maximize material removal rates, M, are derived. It is shown that if the dose per unit area per raster is below a threshold value, then epsilon {sub d} and M depend only on the average current density J (the area of the box divided by the beam current). A consideration of the J regimes used for front-side and back-side FIB work shows why changes in epsilon {sub d} have not previously been a problem but are inevitable when milling the large trenches characteristic of flip chip circuit modification work. While epsilon {sub d} changes dramatically, there is a region of J values for which M is approximately constant. (11 refs.)
Subject: Current density; Elemental semiconductors; Flip chip devices; Focused ion beam technology; Integrated circuit packaging; Machining; Optimisation; Semiconductor process modelling; Silicon; Sputter etching; Surface chemistry; Xenon compounds; XeF{sub 2} enhanced FIB milling; Silicon; Modeling; Optimization; Dose enhancement factor; Milling; Focused ion beam XeF{sub 2} gas assisted etching; FIB XeF{sub 2} GAE; Material removal mechanisms; Sputtering; Gas assisted sputtering; Spontaneous chemical reactions; Milling parameters; Gas parameters; Material removal rate; Dose per unit area per raster; Average current density; Beam current; Back side FIB; Front side FIB; Trench milling; Flip chip circuit modification; Si
Chemical: XeF2; XeF{sub 2}; F2; F{sub 2}; Xe; F; Si
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